Radiological Health Data and Reports

VOLUME 10, NUMBER 3

MARCH 1969

(Pages 89–134)

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tăr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'co
10^{-15}	femto	f	fĕm'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 3, March 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

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Acting Director
Bureau of Radiological Health

by the Office of Criteria and Standards
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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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Environmental Control Administration ● Bureau of Radiological Health

Improvement in New York City X-Ray Installations During the First Seven Years of a Radiation Control Program

Hanson Blatz and *Daniel E. Lynch*[1]

The percentage of private medical radiographic units in New York City free from described deficiencies, increased from 8 to 73 percent between 1959 and 1966; for dental radiographic units the increase was from 47 to 89 percent. The percentage of medical radiographic units considered to have adequate x-ray beam filtration increased from 75 to 95 percent in this period; for fluoroscopes the improvement was from 81 to 94 percent; and for dental machines, from 66 to 96 percent. Also during this period, the percentage of machines possessing adequate beam limitation increased as follows: for medical radiographic units, 34 percent to 90 percent; for fluoroscopic units, 40 to 83 percent; and for dental units, 73 to 94 percent.

The inspection of medical and dental x-ray equipment in New York City is under the direction of the Office of Radiation Control, which was established in 1958. Article 175 of the New York City Health Code, entitled "Radiological Hazards," establishes standards for x-ray installations. Except as otherwise specified by the New York City Department of Health, the mandatory recommendations pertaining to medical and dental installations and their equipment and use, of the National Council on Radiation Protection and Measurements, (as shown in the National Bureau of Standards Handbook 76 (*1*)) or equivalent safeguards, are incorporated into the New York City health code and apply to medical and dental installations, their equipment and its use.

Exceptions have been made in enforcement of mandatory recommendations only in a few instances where minor matters of interpretation were involved; in some cases postponement of mandatory recommendations considered to be of secondary importance was permitted for practical reasons. It has been generally interpreted that a dental x-ray machine requires added filtration of 1 mm of aluminum in addition to the 0.5 mm inherent filtration considered to be present in all standard x-ray equipment. In the case of medical x-ray machines, 2 mm of additional aluminum filtration is required. No consideration is given for variability in inherent filtration including the panel of a fluoroscope. Delays have been permitted in the installation of interlock switches on x-ray therapy equipment when, in a private office the only door to the x-ray therapy room is immediately adjacent to and visible from the operator's location at the controls. Another type of delay allowed has been the installation of fluoroscopic timers in private offices of nonradiologists. Since many thousands of fluoroscopes in New York City were without such timers at the beginning of the program, it was virtually impossible to require them to be installed on all equipment immediately.

The notation "adequate operator protection" involves different criteria for different types of installations. For example, adequate operator protection in the case of a dental installation merely means that the exposure switch must be at the end of a sufficiently long electrical cord and the room so arranged that the operator may always be at least 6 feet away from the patient and the tube head, and away from the useful beam. In the case of a medical x-ray machine in a fixed location, the operator must be provided with a shielded booth or equivalent (fixed floor screen of adequate size), or the control may be in another room and the exposure switch must be so located that, when pressing the exposure switch, the operator cannot look around the

[1] Hanson Blatz is director, and Daniel Lynch, assistant director, Office of Radiation Control, New York City Department of Health, N. Y.

edge of the wall of the booth at the patient. This is to avoid exposure of the operator to scattered radiation. In the case of mobile (bedside) equipment, the operator must have a long cord (as for dental installations), and also be provided with a protective apron.

From the foregoing, it can be seen that the method of applying standards to x-ray equipment and its use in New York City are not substantially different from those in other parts of the United States which have radiological health programs. However, the means of attaining compliance is unique to New York City.

Each Public Health sanitarian who is engaged in the inspection and surveillance program is a peace officer and thereby commissioned to serve a summons in cases of Health Code violations. Throughout the 9 years of this program, only one court summons has been served, but this was a special case involving violations of the Education Laws and the Criminal Code.

During the planning of the program, the Office of Radiation Control worked very closely with both the medical and dental professions to foster their cooperation. An informal arrangement was agreed upon, namely not to serve a summons to any member of a professional group employing x-ray equipment without first giving his professional organization the opportunity of interceding. In many cases, the County Medical Society or the local Dental District Society has written a letter to one of its members (and in some cases to nonmembers) after efforts to persuade the offender to correct deficiencies had failed. In every case but two, such letters have been effective and the offending professional has corrected all of the deficiencies listed in our report to him. In each of those two cases, the Health Commissioner issued a summons to the practitioner to appear at a private hearing to show cause why the x-ray equipment should not be sealed as constituting a public health hazard. In each case all of the deficiencies were either corrected or were being corrected by the date of the hearing and the hearing was cancelled. In effect, therefore, virtually 100-percent compliance with the more important requirements was attained although in some cases it has taken several years to attain such compliance. In many cases, we have considered minor deficiencies not sufficiently serious to take such drastic action but continued in an attempt to persuade offenders to make the necessary corrections.

Initially, when the inspection program was on a small scale, the survey results were hand tabulated from monthly forms. Special attention was given to beam collimation during chest radiography. It has been found that in many cases the primary beam exposed the gonads, and lenses of the eyes. Later, when compilation of the data was transferred to a computer system, this item of evaluation was extended to include satisfactory collimation for all techniques used; that is, for every combination of tube-to-film distance and film size routinely used.

The reason for considering these two criteria together is that over the years we have given equal emphasis in enforcement to adequate collimation of all fields. The criterion for a circular beam is that the beam diameter at the film be not over 2 inches greater than the diagonal dimension of the film used, except for dental films. For dental equipment the beam diameter at the cone tip must not be more than 3 inches.

The inspectors affix labels to each collimator listing the tube-to-film distance and film size combinations for which each may be used. Inspectors make spot checks of exposed films for cut-off of one or more corners to check on collimation under conditions of actual use.

Results

The findings of inspections conducted during three survey periods, 1959–1960, 1962–1963, and 1965–1966, are shown in table 1. The inspections made during the first two periods were initial inspections; those made during the 1965–1966, period included many installations that had been surveyed previously. The data for the 1965–1966 survey provide no breakdown with respect to second inspections, or to any corrections that may have been made following the initial inspection.

The original aim was to obtain information about uninspected installations. The data on the 1959–1960 and 1962–1963 inspections reflect this. At the outset there was a certain amount of selection according to age of the machine, as registered on forms filled out by the facility operators prior to the survey. Thus the earliest survey results were biased in the direction of greater emphasis on older machines.

Table 1. Results from inspections of x-ray machines

Type of installation and compliance item	1959–1960		1962–1963		1965–1966	
	Inspections	Percent in compliance	Inspections	Percent in compliance	Inspections	Percent in compliance
Mobile						
filtration	288	69.0	172	78.6	66	89.4
exposure switch	288	97.2	172	95.9	66	96.7
Dental						
filtration	2,716	66.3	2,377	80.9	2,358	95.9
exposure switch	2,716	95.0	2,377	92.1	2,358	98.3
beam limit	2,716	72.5	2,377	80.9	2,358	93.5
Medical radiographic						
filtration	1,648	75.0	1,179	82.1	953	94.8
exposure switch	1,648	37.0	1,179	45.2	953	79.2
beam limit	[a] 1,081	34.0	[a] 741	37.7	953	89.9
Fluoroscopic						
filtration	1,687	80.6	1,147	80.8	929	93.9
gloves	1,687	93.5	1,147	93.3	929	97.6
apron	1,687	91.5	1,147	92.8	929	97.1
beam limit	1,687	40.5	1,147	50.6	929	82.6
Therapy						
filter	127	80.3	165	93.3	121	97.5

[a] Chest x ray only.

The improvements seen in the 1965–1966 survey (tables 1 and 2) may reasonably be attributed to such factors as: 1) corrections following findings at the initial inspection, 2) newer machines, and 3) education associated with the activities of the Inspection Division.

The general trend of improvement in various major facility categories; hospital and clinic, private medical office, and dental, can be visualized readily by reference to table 2. Thus, it may be seen that the percentage of private medical units free from deficiencies outlawed by the City Health Code in 1958 increased from 8 to 73 percent; the corresponding improvement for dental units was from 47 to 89 percent.

As to the specific protective measures (table 1), the percentage of medical radiographic units considered to have adequate x-ray beam filtration increased from 75 percent to 95 percent; for fluoroscopes the improvement was from 81 percent to 94 percent; and for dental machines from 66 percent to 96 percent. With respect to the important factor of limitation of beam size to the area being examined, the following rates of improvement were observed: for medical radiographic equipment, adequate beam limitation was found in 90 percent in 1965–1966 as compared with 34 percent in 1959–1960; for fluoroscopic equipment the increase went from 40 percent to 83 percent; for dental equipment it rose from 73 percent to 94 percent. Corresponding improvement was also observed in protection of the operator in all types of facilities.

An interesting feature, as shown in table 2, is the increase in the percentage of machines free of deficiencies. In the most recent survey, these were: dental, 89 percent; medical (office), 73 percent; and hospitals or clinics, 81 percent.

Table 2. Results from inspections of x-ray machines by type of x-ray facility[a]

Type of facility	1959–1960		1962–1963		1965–1966	
	Inspections	Percent in compliance	Inspections	Percent in compliance	Inspections	Percent in compliance
Hospital and clinic	[b]	[b]	1,357	54	401	81
Medical, private office (radiographic and fluoroscopic)	3,623	8	1,520	20	1,702	73
Dental	2,716	47	2,377	57	2,358	89

[a] Gross findings; inspected machine may have a deficiency in one or a combination of parameters.
[b] Not recorded.

Summary and discussion

After the initial inspection of x-ray equipment in New York City was completed in 1959–1960, the results showed a preponderance of deficiencies which constituted violations of the Radiological Hazards Section of the Health Code of 1958. Physicians and dentists were notified of each violation and instructed how to make necessary changes.

Subsequent followup inspections and repeated instructions brought about a significant improvement. This is considered to have resulted in a sharply reduced exposure of patients and operators to unnecessary radiation during medical and dental examinations. The remaining deficiencies, however, are not insignificant and a continuing effort is being exerted to eliminate them.

Refinements in medical and dental radiology are continually being developed. When any technique has been proven to be effective in reducing radiation exposure, it is intended that it will be made mandatory under the Health Code.

Acknowledgments

Acknowledgment is gratefully given for the collection of data by the Radiation Inspection Division under the successive leadership of A. Africk, M. Rosenfeld, and B. S. Reich, and for the assembly and tabulation of the data by M. Smolens, special assistant. The 1965–1966 data represent a small part of the large mass of data processed by our Health Department's Division of Organization and Methods, and machine tabulated by the staff of the Bureau of Radiological Health, Public Health Service, Rockville, Md.

REFERENCE

(*1*) NATIONAL COMMITTEE ON RADIATION PROTECTION AND MEASUREMENTS. Medical x-ray protection up to three million volts, NCRP Report No. 26. National Bureau of Standards Handbook 76 (February 1961).

Technical Notes

Tritium in New York State Waters, 1965

Kurt Anderson[1]

The Bureau of Radiological Health of the New York State Health Department conducted a survey of tritium concentrations in various waters of New York State during 1965. Three parts of the study included sampling of major river systems and large lakes, intense sampling of the area near the first commercial fuels reprocessing plant, and sampling of the ground waters on Long Island.

Begemann and Libby (*1*) reported that naturally occurring tritium, which results from the interaction of cosmic rays with the upper atmosphere, produces a tritium concentration in rain of approximately 2.5×10^{-2} nCi/liter. The study was undertaken because it was felt that the weapons tests in the late 1950's and early 1960's may have significantly increased environmental tritium levels and that there would be significant increases from nuclear facilities in the future.

Analytical procedures

The State Health Department's Radiological Laboratories did not have the capability for tritium counting at the time of this study and analyses were performed by two commercial laboratories; Tracerlab Incorporated, and Isotopes Incorporated.

The Tracerlab procedure used liquid scintillation counting with no sample refinement. The minimum detectable limit was taken as 1.6 nCi/liter with an associated counting error of ±50 percent. Any samples containing less than 1.6 nCi/liter were reported as <1.6 nCi/liter.

The Isotopes Incorporated procedure consisted of unmodified liquid scintillation counting to determine the range of radioactivity. If the sample had a tritium concentration greater than 9.6 nCi/liter, only liquid scintillation counting was used with a counting error of ±10 percent. For samples containing 0.16 to 9.6 nCi/liter, the sample was enriched by electrolytic means, then gas counted. The associated error with this method was ±10 percent. For samples less than 0.16 nCi/liter, the sample was first electrolytically enriched, and then further concentrated by a "dry box" distillation method, followed by gas counting. Use of this procedure allows tritium concentration determinations for samples containing 3.2×10^{-3} nCi/liter ±10 percent.

Statewide study

The State's major rivers, creeks, and lakes were sampled to see what variations in tritium content occurred throughout the State (figure 1). Since most tritium in the atmosphere from nuclear weapons probably reaches the surface waters in precipitation, one would expect that running water, such as in creeks and rivers (made up of recent precipitation runoff) may be higher in tritium than large, deep lakes that contain older water, providing greater dilution.

Nuclear Fuels Services study

Nuclear Fuels Services, a fuels-reprocessing plant, releases several curies of tritium a day (*2*). Before the plant went into operation, all creeks, lakes, and water supplies within 10 miles of the plant were sampled, some more than once

[1] Mr. Anderson is assistant sanitary engineer, Bureau of Radiological Health, New York State Department of Health, Albany, N.Y.

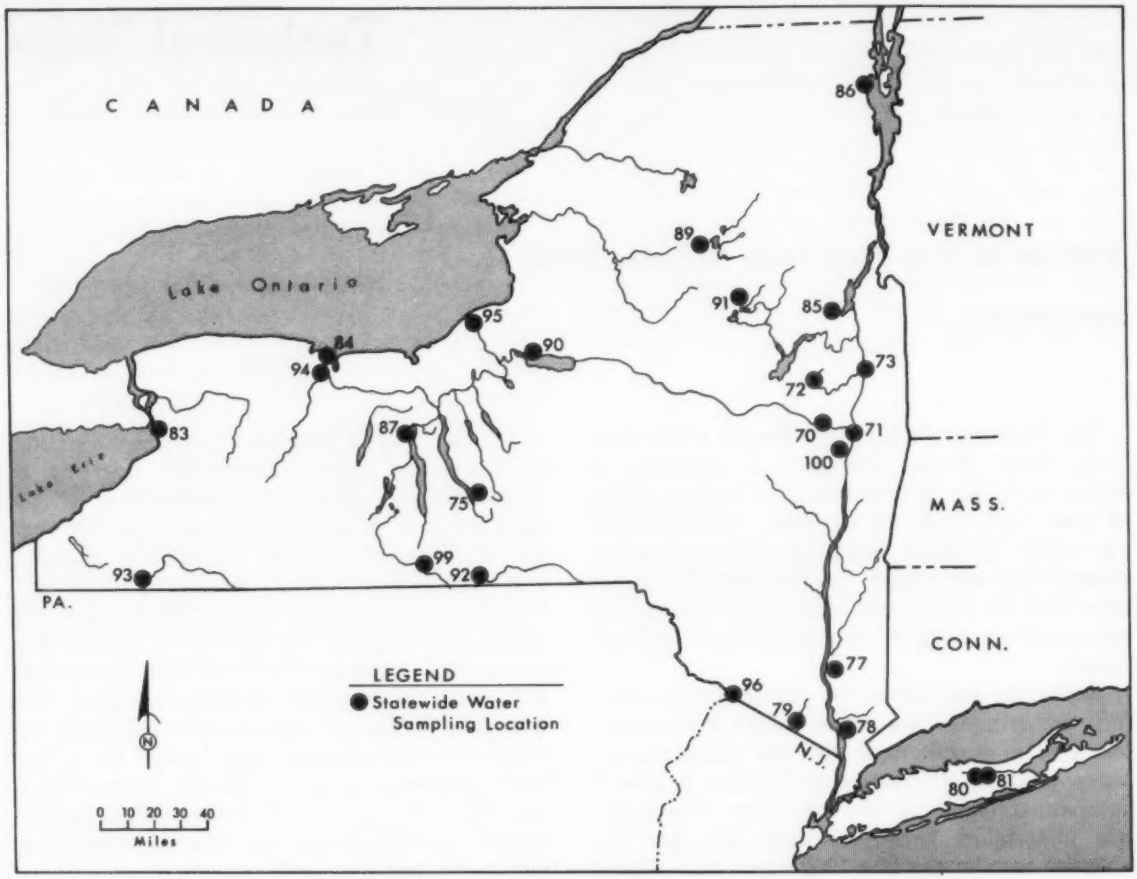

Figure 1. Sampling locations in New York State waters

(figure 2). This study established a background level for future evaluation of the plant's influence on the area.

Long Island well waters

Six wells each in Nassau and Suffolk counties were sampled for tritium (figure 3). It was felt that it might be possible to date the water to determine rainwater infiltration rates. Infiltration rates would be very helpful to water supply managers for predicting the abundance or scarcity of water in relation to rainfall.

Discussion of results

In the statewide study the samples taken from Lakes Seneca, Cayuga, Ontario, and Erie had tritium concentrations less than 1.3 nCi/liter, while Lake George and Lake Champlain had levels above that amount (table 1). It is felt that large lakes do have lower levels of tritium than streams, but lake samples should not be taken next to the shore as these samples were taken. Shore samples may indicate the influence of surface runoff and not reflect the average concentration of tritium in the lake as a whole. Further study is necessary to ascertain the correctness of this hypothesis. The overall average value for lakes and rivers is approximately 1.6 nCi/liter. This level is considerably higher than the "natural" level of 2.5×10^{-2} nCi/liter and shows the contribution of fallout.

The creeks and other water bodies sampled around the fuels reprocessing plant had an average tritium concentration of approximately 1.9 nCi/liter. The concentrations varied from less than

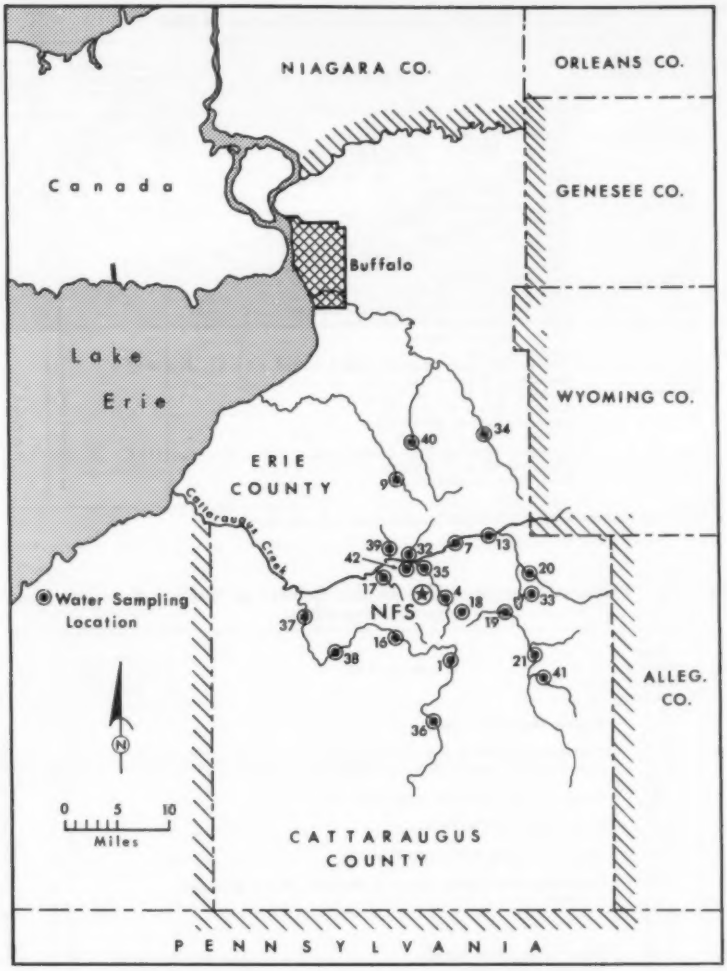

Figure 2. Sampling locations in the vicinity of Nuclear Fuel Services Reprocessing Plant

1.6 nCi/liter up to a high of 3.2 nCi/liter. The variations in tritium levels seem to agree with a similar variation in the statewide samples (tables 1 and 2). A value for background tritium concentration probably lies between 1.6 and 3.2 nCi/liter.

The wells on Long Island exhibit very low concentrations of tritium compared to surface waters (table 3). The one exception, Flanders, is a shallow well and the time necessary for surface water intrusion is probably short (only a few years). The other wells, especially wells 200 feet or more deep, exhibit very low concentrations. The age of this water, assuming it was originally free of weapons-produced tritium and contained 2.5×10^{-2} nCi/liter, would be approximately 30 or more years old.

Generally speaking, tritium levels in surface waters of New York State may have increased by a factor of 70 to 100 times since the development of nuclear weapons, while deep well water has not yet been affected.

Table 1. State-wide samples collected in 1965

Site number	Collection date (1965)	Location of site	Laboratory performing analysis [a]	Tritium concentration (nCi/liter) [b]
70	September	Mohawk River at Rt. 146 bridge	T	2.0 ±0.6
71		Mohawk River at Vischer Ferry Dam	T	2.5 ± .6
72		Glowegee Creek at Rt. 147 bridge	T	2.0 ± .6
73		Kayaderosseras Creek at Rt. 50 bridge	T	3.5 ± .7
75	August	Cayuga Lake at Ithaca	I	1.2 ± .1
77	September	Hudson River at Beacon	T	<1.6
78		Hudson River at Ossining	T	2.4 ± .7
79	October	Indian Kill at Tuxedo	T	<1.6
80	September	Peconic Creek at Wm. Floyd Parkway	T	<1.6
81	May	Peconic Creek at Wading River Road	I	.71± .04
83	September	Lake Erie at Buffalo	I	1.2 ± .1
84		Lake Ontario at Rochester	I	.60± .04
85	June	Lake George at Village of Lake George	I	1.6 ± .1
86	September	Lake Champlain at Plattsburgh	I	2.1 ± .1
87	June	Seneca Lake at Geneva	I	.54± .04
89		Racquett Lake	I	2.5 ± .1
90	September	Oneida Lake near Cicero Center	I	2.6 ± .1
91	June	Sacandaga Reservoir at Dam	I	2.6 ± .1
92	September	Susquehanna River at Waverly	T	<1.6
93		Allegany River at Onoville	T	<1.6
94		Genesee River at Rochester	T	<1.6
95		Oswego River at Oswego	T	<1.6
96		Delaware River at Port Jervis	T	<1.6
99		Chemung River at Elmira	T	2.9 ± .7
100		Rain water at Albany	I	1.5 ± .1

[a] T—Tracerlab Incorporated. I—Isotopes Incorporated. [b] Counting error.

Table 2. Tritium concentrations in the vicinity of Nuclear Fuels Services reprocessing plant

Site number	Date collected (1965)	Location of site	Laboratory performing analysis [a]	Tritium concentration (nCi/liter) [b]
1	3/23	Beaver Meadows Creek	I	2.5±0.1
	5/26		I	2.7± .1
4	3/23	Buttermilk Creek at Fox Valley Road	I	2.0± .1
7	4/21	Cattaraugus Creek at Bigelow Bridge	I	3.0± .2
	7/12		T	<1.6
9	3/23	Eighteen Mile Creek at Route 219	I	1.9± .1
	4/24		I	2.7± .1
13	4/21	Elton Creek at The Forks	I	3.0± .1
	7/13		T	<1.6
16	3/23	East Otto Creek at County Route 75	I	2.0± .1
	4/21		I	2.8± .1
17	3/23	Connoisarauley Creek above confluence of Cattaraugus Creek	I	2.4± .1
	4/21		I	2.9± .1
	5/17		T	2.2± .6
	7/12		T	<1.6
18	7/12	West Valley water supply	T	<1.6
19	7/13	Machias water supply	T	<1.6
20	3/23	Delevan water supply	I	1.4± .04
	4/21		I	1.5± .1
	5/17		T	<1.6
21	3/24	Ischua Creek at Route 16	I	2.0± .1
	4/21		I	3.1± .1
	5/17		T	<1.6
32	3/23	Cattaraugus Creek at Felton bridge	I	2.6± .1
	10/29		T	<1.6
33	3/23	Lime Lake	I	1.6± .1
	4/21		I	1.7± .1
	5/18		I	2.1± .1
	7/12		T	2.1± .6
34	3/23	Cazenovia Creek (E. Branch) at Route 16	I	1.6± .1
	4/21		I	3.2± .2
	7/13		T	<1.6
35	3/23	Buttermilk Creek at Thomas Corners Road	I	2.3± .1
	4/21		I	3.2± .2
	5/17		T	<1.6
	10/29		T	<1.6
36	5/17	Great Valley Creek at Route 242	I	2.5± .1
	7/13		T	<1.6
37	4/21	S. Branch Cattaraugus Creek at Forty Bridge	I	2.6± .1
38	4/21	S. Branch Cattaraugus Creek at Village of Otto	I	3.1± .2
	5/18		I	2.3± .1
	7/12		T	1.9± .6
39	5/17	Spooner Creek, Town of Concord at Zoar Valley Road	I	2.6± .1
	7/13		T	3.1± .6
40	7/13	W. Branch Cazenovia Creek at Glenwood	T	3.0± .6
41	7/14	Franklinville Water Supply Reservoir	T	1.7± .6
42	12/16	Cattaraugus Creek at Springville Dam	T	<1.6
	12/23		T	<1.6
	12/30		T	1.8± .6

[a] Tracerlab Incorporated. I—Isotopes Incorporated. [b] Counting error.

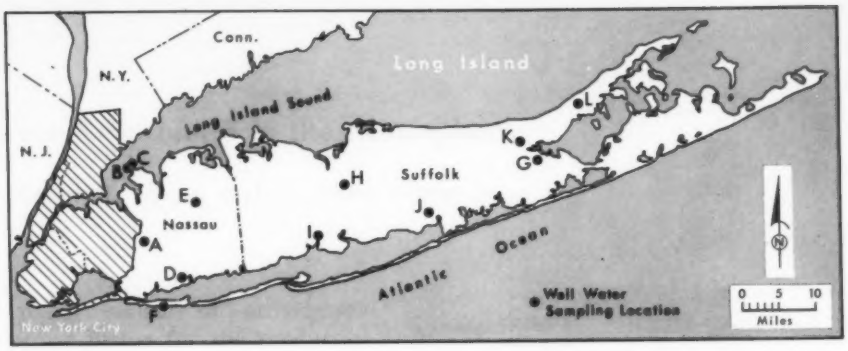

Figure 3. Long Island well water sampling locations

Table 3. Tritium concentrations in Long Island well water, July 1965[a]

Site	Location of site	Depth of well from surface (feet)	Tritium concentration (nCi/liter)[b]
A	Garden City	90	$9.0\times10^{-3}\pm0.3\times10^{-3}$
B	Sands Point	214	$1.5\times10^{-3}\pm .1\times10^{-3}$
C	Sands Point	140	$.29 \pm .01$
D	Village of Freeport	507	$.6\times10^{-3}\pm .1\times10^{-3}$
E	Jericho Water District	600	$.4\times10^{-3}\pm .1\times10^{-3}$
F	Long Beach City	1,275	$.4\times10^{-3}\pm .1\times10^{-3}$
G	Flanders	35	$1.5 \pm .1$
H	Nesconset	37	$.22 \pm .02$
I	Bayshore	44	$.9\times10^{-3}\pm .1\times10^{-3}$
J	Brookhaven	38	$6.7\times10^{-3}\pm .3\times10^{-3}$
K	Riverhead	113	$5.4\times10^{-3}\pm .3\times10^{-3}$
L	Cutchogue	42	$.13 \pm .01$

[a] All analyses were performed by Isotopes Incorporated.
[b] Counting error.

REFERENCES

(1) BEGEMANN, F. and W. F. LIBBY. Continental water balance, ground water inventory and storage times, surface ocean mixing rates and worldwide circulation patterns from cosmic ray and bomb tritium. Geochim et Cosmochim Acta 12:277 (1957).

(2) NUCLEAR FUEL SERVICES. Safety Analysis, Spent Fuel Processing Plant Nuclear Fuel Services, Part B (1962).

Surveillance for Krypton-85 in the Atmosphere

N. Irving Sax, Robert R. Reeves, and *J. David Denny*[1]

Today, the major source of atmospheric krypton-85 is nuclear fission for the production of power (*1*). Very little is released to the atmosphere at the time of fission but when the fuel elements are reprocessed, it is not unusual for 10^3 to 10^4 curies of krypton-85 to be released through the stack of a reprocessing plant to the surrounding atmosphere in a given day.[2]

The purpose of this study was to develop a practical technique for conducting routine surveillance for atmospheric krypton-85.

Procedure

A simple, inexpensive method was developed for field sampling using plastic bags which could readily be filled in the field in less than 2 minutes with up to 8 ft³ of air each, via a standard battery-powered automobile vacuum cleaner. The bagged samples were inserted into ordinary cardboard cylinders and shipped to Albany for processing where they are emptied into a cryogenic collector for analysis, as described below.

In the laboratory, the air sample from a bag or the ambient air in the laboratory, is taken directly into a cryogenic collector using a 5 Å molecular sieve as an adsorbent at liquid nitrogen temperature. The sample is transferred to a vacuum rack by desorbing it from the molecular sieve and readsorbing on charcoal contained within the rack and cooled with liquid nitrogen (*2*). The sample is then fractionally desorbed from the charcoal. The first part of the sample (less than 1 percent) is discarded since it contains little krypton and the remainder, about 100 cc, is purified by physical and chemical means. The final sample, about 2 cc of gas (STP), is thereby concentrated to at least 90 percent krypton from an initial total air sample of about 100 ft³ containing about 10^{-4} percent krypton by volume. The purification steps to obtain the final sample are shown in figure 1.

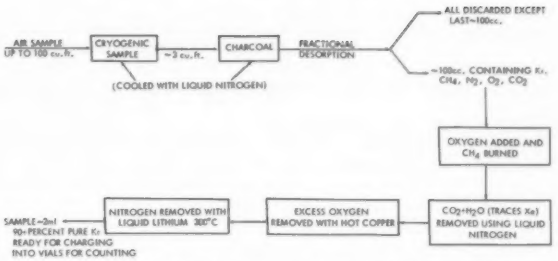
AIR SAMPLE
UP TO 100 cc. R.
CRYOGENIC SAMPLE
~2 cc. R.
CHARCOAL
FRACTIONAL DESORPTION
ALL DISCARDED EXCEPT LAST~100cc.
~100cc. CONTAINING Kr, CH4, N2, O2, CO2
(COOLED WITH LIQUID NITROGEN)
OXYGEN ADDED AND CH4 BURNED
SAMPLE~2ml
90+ PERCENT PURE Kr
READY FOR CHARGING INTO VIALS FOR COUNTING
NITROGEN REMOVED WITH LIQUID LITHIUM 200°C
EXCESS OXYGEN REMOVED WITH HOT COPPER
CO2+H2O (TRACES Xe) REMOVED USING LIQUID NITROGEN

Figure 1. Block diagram of purification for atmospheric krypton

The sample is counted for krypton-85 beta-particles using a standard liquid scintillation-type counter with a solid scintillant instead of a liquid. A glass vial which contains p-terphenyl in polyvinyl toluene in the form of shavings is evacuated and filled with a measured amount of the sample and then counted (*3*). Since the efficiency of counting disintegrations of krypton-85 can be measured by using a krypton standard, the percent of krypton-85 can be determined and the atom percent of krypton-85 in the total krypton can be calculated. Assuming a fixed concentration of krypton in the atmosphere (1.14 ppm), the specific activity of krypton-85 can then be obtained.

Results

The results obtained during the period, April 1, 1967 to March 31, 1968, are shown in figure 2 and table 1. In the period, April through August 1967, relatively large samples (>100 cubic feet of air) were taken and only the purest krypton samples were retained. These samples

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[2] Communication from Nuclear Fuel Services, Inc., West Valley, N.Y.

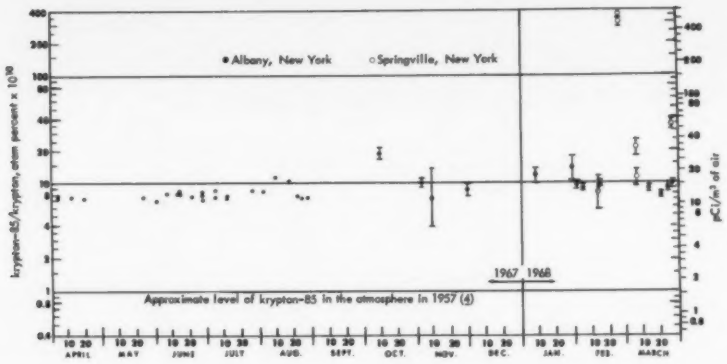

Figure 2. Atmospheric krypton-85 measurements

Table 1. Krypton in the atmosphere

Sampling location	Date of sample collection	Concentration[a] (pCu/m³)
	1967	
N.Y., Albany	4/ 5	11.8± 5%
	4/ 5	12.1± 5%
	4/13	11.7± 5%
	4/20	11.6± 5%
	5/25	11.7± 5%
	6/ 1	11.0± 5%
	6/ 8	12.3± 5%
	6/15	12.9± 5%
	6/15	12.7± 5%
	6/22	12.1± 5%
	6/29	12.4± 5%
	6/29	10.9± 5%
	7/ 7	12.7± 5%
	7/ 7	11.9± 5%
	7/13	11.9± 5%
	7/13	12.1± 5%
	7/28	13.2± 5%
	8/ 2	12.8± 5%
	8/11	17.7± 5%
	8/17	16.4± 5%
	8/22	11.9± 5%
	8/23	11.5± 5%
	8/28	11.5± 5%
	10/10	29 ± 2%
	11/ 3	16 ± 2%
	11/ 9	11 ± 10%
	11/30	13 ± 2%
	1968	
N.Y., Albany	1/ 9	18 ± 3%
	1/30	21 ± 6%
	1/31	15 ± 1%
N.Y., Springville	2/ 5	14 ± 1%
N.Y., Albany	2/14	12 ± 5%
N.Y., Springville	2/15	15 ± 1%
	2/27	560 ±100%
	2/27	480 ± 40%
	3/ 7	43 ± 8%
	3/ 7	17 ± 4%
N.Y., Albany	3/14	14 ± 1%
	3/21	12 ± 1%
	3/25	14 ± 1%
	3/28	15 ± 1%
N.Y., Springville	3/28	54 ± 7%

[a] One sigma analytical error.

were given long counts with frequent standardization. The precision of these results is better than ±5 percent based upon a consideration of overall analytical error and confirmed by a series of duplicate samples.

Several samples were taken about 5 miles north of the reprocessing plant. Some of these samples contained relatively high levels of krypton-85, up to 30 times the concentrations regularly measured. The limits of error on all measurements taken during and since October have been estimated and included as error bars on the graph.

Discussion

The present concentration of krypton-85 in the atmosphere is about 11 pCi/m³ which is minor in terms of population health hazard (*1*). It is, however, released in clouds from reprocessing plants so that considerably higher levels can periodically be observed until sufficient mixing with the atmosphere has occurred.

The surveillance described above was for the purpose of developing a simple, inexpensive, and reasonably sensitive environmental monitoring technique for krypton-85 in the atmosphere. One or two 8-cubic foot air samples collected by this technique are enough for an analysis to an analytical precision of ±10 percent.

Current atmospheric concentrations of krypton-85 of about 11 pCi/m³ have been measured and occasional transients up to 2 times higher have been observed. It should be noted that the increase in the background krypton-85 in the atmosphere from April 1, 1967 to March 31, 1968 was less than 10 percent (figure 2). Additional air samples taken about 5 miles to the north of a reprocessing plant have shown much higher levels (up to 450 pCi/m³) as might be anticipated.

Acknowledgement

The authors wish to acknowledge the helpful discussions with Herbert S. Clark, Rensselaer Polytechnic Institute, and Joseph Hutchinson and Roger Waldron for technical assistance.

This investigation was supported in part by the U.S. Public Health Service Research Grant RH-412, National Center for Radiological Health, Rockville, Md.

REFERENCES

(*1*) COLEMAN, J. R., and R. LIBERACE. Nuclear power production and estimated krypton-85 levels. Radiol Health Data Rep 7:615–621 (November 1966).

(*2*) DENNY, J. D. Krypton separation efficiency from air as a function of sampling rate. Masters Thesis, Rensselaer Polytechnic Institute (1968).

(*3*) SAX, N. I., R. R. REEVES, and J. D. DENNY. Determination of low level krypton-85. Anal Chem 40:1915 (1968).

(*4*) ENHALT, D., K. O. MUNNICH, W. ROETHER, J. SCHOLCH, and W. STICH. Artificially produced radioactive noble gases in the atmosphere. J Geophys Res 68:3817 (July 1963).

SECTION I. MILK AND FOOD

Milk Surveillance, November 1968

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation expressed in terms of 2-standard deviations for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20 to 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over the time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation will also reflect whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed

or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviation
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8*, *9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk one can utilize the graded approach of daily intake on the basis of radionuclide content

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/yr)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)	Range II (pCi/day)	Range III (pCi/day)
Strontium-89	Bone	1.5	0.5	[b] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	.5	.17				
Strontium-90	Bone	1.5	.5	[b] 200	0–20	20–200	200–2,000
	Bone marrow	.5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[c]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.
[b] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[c] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentra-

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first year total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

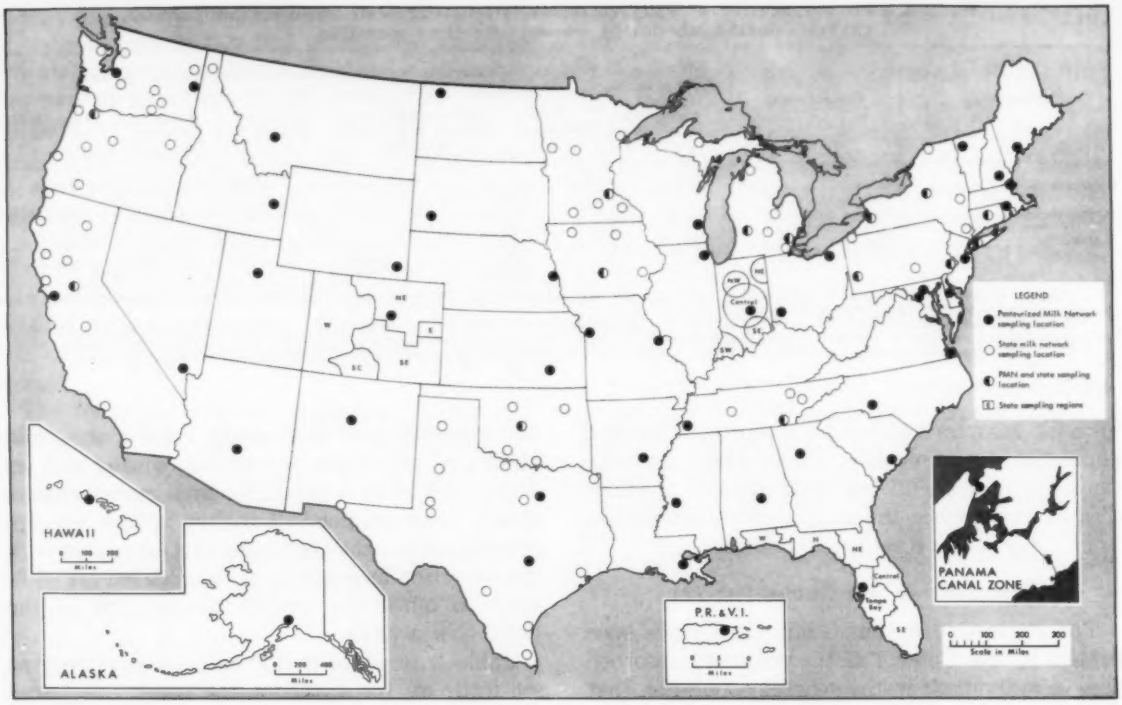

Figure 2. State and PHS sampling locations in the United States

tion from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-month average, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137 for November 1968 and the 12-month period, December 1967 to November 1968. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations

Table 3. Concentrations of radionuclides in milk for November 1968 and 12-month period, December 1967 through November 1968

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	7	9	0(4)	0	14(4)	13
Alaska:	Palmer[c]	P	0	5	0(3)	0	11(3)	14
Ariz:	Phoenix[c]	P	0	1	0(4)	0	0(4)	2
Ark:	Little Rock[c]	P	18	21	0(4)	0	11(4)	19
Calif:	Sacramento[c]	P	0	2	0(5)	0	0(5)	6
	San Francisco[c]	P	0	1	0(4)	0	0(4)	5
	Del Norte	P	26	20	0	0	28	24
	Fresno	P	3	1	0	0	11	6
	Humboldt	P	5	4	0	0	13	11
	Los Angeles	P	3	1	0	0	0	6
	Mendocino	P	0	3	0	0	0	4
	Sacramento	P	5	2	0	0	0	5
	San Diego	P	0	0	0	0	11	3
	Santa Clara	P	0	0	0	0	12	7
	Shasta	P	3	4	0	0	11	5
	Sonoma	P	0	2	0	0	0	5
Colo:	Denver[c]	P	3	4	0(4)	0	5(4)	7
	West	R	(d)		(c)	(c)	(c)	(c)
	Northeast	R	(d)		(c) (2)	1	(c) (2)	(c)
	East	R	(d)		NS	(c)	NS	(c)
	Southeast	R	(d)		NS	(c)	NS	(c)
	South Central	R	(d)		NS	(c)	NS	(c)
Conn:	Hartford[c]	P	9	10	0(5)	0	11(5)	11
	Central	R	8	7	0(5)	0	17(5)	10
Del:	Wilmington[c]	P	7	10	0(4)	0	10(4)	8
D.C:	Washington[c]	P	9	10	0(4)	0	0(4)	6
Fla:	Tampa[c]	P	10	8	0(3)	0	78(3)	67
	West	R	10	14	0	4	22	21
	North	R	11	15	0	0	45	25
	Northeast	R	9	9	0	2	114	86
	Central	R	9	9	15	2	26	85
	Tampa Bay area	R	8	8	0	0	77	72
	Southeast	R	10	9	0	2	117	109
Ga:	Atlanta[c]	P	11	14	0(4)	0	19(4)	20
Hawaii:	Honolulu[c]	P	5	4	0(4)	1	3(4)	4
Idaho:	Idaho Falls[c]	P	6	6	0(4)	0	14(4)	9
Ill:	Chicago[c]	P	7	9	0(4)	0	9(4)	10
Ind:	Indianapolis[c]	P	7	8	0(4)	0	3(4)	7
	Northeast	P	14	9	0	0	15	13
	Southeast	P	12	11	0	0	15	12
	Central	P	10	8	0	0	0	9
	Southwest	P	8	9	0	0	0	13
	Northwest	P	10	9	0	0	14	12
Iowa:	Des Moines[c]	P	6	7	0(4)	0	3(4)	7
	Iowa City	P	7	7	0	0	12	5
	Des Moines	P	7(4)	7	0(4)	0	4(4)	2
	Spencer	P	3	6	0	0	0	3
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	8	8	0(4)	0	3(4)	4
Ky:	Louisville[c]	P	11	12	0(4)	0	4(4)	6
La:	New Orleans[c]	P	20	20	0(2)	0	17(2)	23
Maine:	Portland[c]	P	12	12	3(4)	1	31(4)	29
Md:	Baltimore[c]	P	11	10	0(4)	0	4(4)	6
Mass:	Boston[c]	P	9	12	0(4)	0	21(4)	24
Mich:	Detroit[c]	P	8	9	0(4)	0	9(4)	12
	Grand Rapids[c]	P	12	11	0(4)	0	12(4)	15
	Bay City	P	NS	4	NS	(c)	NS	6
	Charlevoix	P	NS	5	NS	(c)	NS	8
	Detroit	P	NA	4	(c) (4)	(c)	0(4)	4
	Grand Rapids	P	NA	5	(c) (4)	(c)	6(4)	8
	Lansing	P	4	4	(c) (2)	(c)	6(2)	2
	Marquette	P	NA	7	(c) (2)	(c)	27(2)	22
	Monroe	P	NA	3	(c) (2)	(c)	0	1
Minn:	Minneapolis[c]	P	11	12	0(4)	0	15(4)	13
	Bemidji	P	15	15	0	0	25	22
	Mankato	P	5	6	0	0	0	0
	Rochester	P	12	9	0	0	0	0
	Duluth	P	17	19	0	0	30	30
	Worthington	P	7	6	0	0	(c)	(c)
	Minneapolis	P	9	12	0	0	13	13
	Fergus Falls	P	8	10	0	0	(c)	(c)
	Little Falls	P	9	9	0	0	14	14
Miss:	Jackson[c]	P	16	17	0(4)	0	15(4)	15
Mo.:	Kansas City[c]	P	5	8	0(5)	0	0(5)	5
	St. Louis[c]	P	13	9	0(5)	0	3(5)	7
Mont:	Helena[c]	P	4	5	0(3)	0	13(3)	8
Nebr:	Omaha[c]	P	4	7	0(5)	0	0(5)	5
Nev:	Las Vegas[c]	P	0	1	0(4)	0	0(4)	4
N.H:	Manchester[c]	P	10	14	0(4)	0	25(4)	35
N.J:	Trenton[c]	P	9	10	0(4)	0	0(4)	10
N. Mex:	Albuquerque[c]	P	0	2	0(4)	0	0(4)	2

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for November 1968 and 12-month period December 1967 through November 1968—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES—Continued								
N.Y:	Buffalo[c]	P	7	9	0(5)	0	6(5)	10
	New York City[c]	P	9	12	0(4)	0	12(4)	14
	Syracuse[c]	P	8	9	0(4)	0	9(4)	6
	Albany	P	NA	7	NA	0	NA	(c)
	Buffalo	P	NA	7	NA	0	NA	(c)
	Massena	P	NA	10	NA	0	NA	25
	Newburg	P	NA	10	NA	16	NA	(c)
	New York City	P	NA	10	NA	0	NA	21
	Syracuse	P	NA	7	NA	0	NA	(c)
N.C:	Charlotte[c]	P	18	15	0(4)	1	10(4)	11
N. Dak:	Minot[c]	P	12	11	0(4)	0	9(4)	13
Ohio:	Cincinnati[c]	P	8	9	0(4)	0	6(4)	6
	Cleveland[c]	P	8	10	0(5)	0	3(5)	8
Okla:	Oklahoma City[c]	P	9	10	0(3)	0	12(3)	5
	Oklahoma City	P	(d)		NA		NA	
	Enid	P	(d)		NA		NA	
	Tulsa	P	(d)		NA		NA	
	Lawton	P	(d)		NA		NA	
	Ardmore	P	(d)		NA		NA	
Ore:	Portland[c]	P	9	8	0(5)	0	9(5)	15
	Baker	P	0	4	(c)	(c)	(c)	4
	Coos Bay	P	8	10	(c)	(c)	(c)	12
	Eugene	P	5	3	(c)	(c)	(c)	11
	Medford	P	3	3	(c)	(c)	(c)	10
	Portland composite	P	4	7	(c)	(c)	(c)	8
	Portland local	P	0	5	(c)	(c)	(c)	9
	Redmond	R	NA	4	(c)	(c)	19	4
	Tillamook	P	NA	10	(c)	(c)	29	26
Pa:	Philadelphia[c]	P	7	10	0(4)	0	9(4)	9
	Pittsburgh[c]	P	10	12	0(4)	0	13(4)	13
	Dauphin	P	9	8	0	0	13	17
	Erie	P	13	13	0	0	0	21
	Philadelphia	P	11	9	0	0	17	17
	Pittsburgh	P	7	12	0	0	13	15
R.I:	Providence[c]	P	10	11	0(4)	0	17(4)	18
S.C:	Charleston[c]	P	12	14	0(4)	0	24(4)	26
S. Dak:	Rapid City[c]	P	6	9	0(4)	0	9(4)	11
Tenn:	Chattanooga[c]	P	15	13	0(4)	0	9(4)	13
	Memphis[c]	P	11	12	0(4)	0	11(4)	5
	Chattanooga	P	11	12	0(4)	1	16(4)	17
	Clinton	P	14	13	0	2	23	21
	Knoxville	P	8	11	0(2)	4	12(2)	16
	Nashville	P	9	8	0(2)	1	0(2)	12
Tex:	Austin[c]	P	6	4	0(3)	0	0(3)	2
	Dallas[c]	P	6	8	0(4)	0	6(4)	6
	Amarillo	R	NA	4	NA	0	NA	0
	Corpus Christi	R	NA	4	NA	0	NA	0
	El Paso	R	NA	2	NA	0	NA	0
	Fort Worth	R	NA	7	NA	0	NA	0
	Harlingen	R	NA	3	NA	0	NA	0
	Houston	R	NA	11	NA	0	NA	14
	Lubbock	R	NA	4	NA	0	NA	0
	Midland	R	NA	3	NA	0	NA	0
	San Antonio	R	NA	4	NA	0	NA	0
	Texarkana	R	NA	12	NA	0	NA	12
	Uvalde	R	NA	3	NA	0	NA	0
	Wichita Falls	R	NA	10	NA	0	NA	0
Utah:	Salt Lake City[c]	P	4	6	0(4)	0	12(4)	12
Vt:	Burlington[c]	P	8	11	0(4)	0	14(4)	9
Va:	Norfolk[c]	P	8	11	0(5)	0	9(5)	9
Wash:	Seattle[c]	P	7	9	0(4)	0	22(4)	22
	Spokane[c]	P	8	7	0(4)	0	9(4)	10
	Benton County	R	0	0	0	0	17	6
	Deer Park	R	5	3	0	0	16	3
	Elma	R	7	5	0	0	23	20
	Franklin County	R	NS	0	NS	0	NS	(c)
	Moses Lake	R	3	1	0	0	(c)	(c)
	Pierce County	R	5	3	0	0	18	9
	Sandpoint, Idaho	R	12	8	0	0	32	23
	Skagit County	R	4	4	0	0	(c)	14
W.Va:	Charleston[c]	P	7	12	0(3)	0	8(3)	5
Wisc:	Milwaukee[c]	P	6	8	0(5)	0	15(5)	11
Wyo:	Laramie[c]	P	5	4	0(4)	0	28(4)	9
CANADA								
Alberta:	Calgary	R	8	9	(d)		17	19
	Edmonton	R	8	8	(d)		18	22
British Columbia:	Vancouver	R	15	14	(d)		48	52
Manitoba:	Winnipeg	R	10	8	(d)		22	24
New Brunswick:	Frederickton	R	15	15	(d)		21	24

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for November 1968 and 12-month period, December 1967 through November 1968—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA—Continued								
Newfoundland:	St. Johns	R	16	21	(d)		33	43
Nova Scotia:	Halifax	R	12	12	(d)		21	24
Ontario:	Ft. William	R	18	16	(d)		35	30
	Ottawa	R	9	9	(d)		21	20
	Sault Ste. Marie	R	15	15	(d		29	32
	Toronto	R	5	5	(d)		18	16
	Windsor	R	7	6	(d)		11	14
Quebec:	Montreal	R	8	10	(d)		22	21
	Quebec	R	12	13	(d)		29	29
Saskatchewan:	Regina	R	8	8	(d)		27	16
	Saskatoon	R	11	9	(d)		11	18
CENTRAL AND SOUTH AMERICA								
Columbia:	Bogota	P	0	0	0	0	0	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Kingston	P	5	6	0	0	117	110
Venezuela:	Caracas	P	0	0	0	0	0	0
Canal Zone:	Cristobal [e]	P	4	2	0(4)	1	20(4)	10
Puerto Rico:	San Juan [e]	P	0	4	0(3)	0	9(3)	0
PMN network averages: [f]			8	9	0	0	10	12

[a] P, pasteurized milk; R, raw milk.
[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.
[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.
[d] Radionuclide analysis not routinely performed.
[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi liter
Cesium-137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter; Washington—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS pasteurized milk network stations denoted by footnote [e].
NA no analysis.
NS, no sample collected.

for November 1968 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which strontium-89 or barium-140 were detected.

Table 4. Strontium-89 and barium-140 in milk November 1968

Sampling location	Monthly average (pCi/liter)	
	Strontium-89	Barium-140
Nebr: Omaha (PMN)	7	
Canal Zone: Cristobal (PMN)	7	
Calif: Del Norte (State)		14
Humboldt (State)		19
Santa Clara (State)		17
Shasta (State)		15
Maine: Portland (PMN)		3(4) [a]
Mich: Detroit (PMN)		3(4)
Pa: Pittsburgh (PMN)		3(4)
Wisc: Milwaukee (PMN)		3(5)

[a] Number in parentheses indicates number of samples.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 26 pCi/liter in the United States for the month of November 1968 and the highest 12-month average was 21 pCi/liter (Little Rock, Ark.), representing 10.5 percent of the Federal Radiation Council radiation protection guide (table 1).

Cesium-137 monthly averages ranged from 0 to 117 pCi/liter in the United States for the month of November 1968 and the highest 12-month average was 109 pCi/liter (Southeast Florida), representing 3.0 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were generally below the practical reporting level. The following station averages reflect samples in which iodine-131 was detected: Central Florida, (State) 15 pCi/liter, 1 sample; Portland, Maine (PMN) 3 pCi/liter, 4 samples.

Acknowledgment

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation and Occupational Health Section
Division of Environmental Sanitation
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1959. Amer J Public Health 49:225 (February 1959).
(2) Chart of the Nuclides, Ninth Edition, Revised to July 1966. Knolls Atomic Power Laboratory (November 1966).
(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).
(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).
(5) KAUFFMAN, P. and F. KNOWLES. Interlaboratory study of iodine-131, cesium-137 and strontium-90 measurements in milk, March–April 1967. Technical Experiment M–1–67, Analytical Quality Control Service, National Center for Radiological Health (August 1967).
(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).
(7) ROBINSON, P. B. A comparison of results between the Public Health Service raw milk and pasteurized milk networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).
(8) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).
(9) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).
(10) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).
(11) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).
(12) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium-137 Concentrations in Tampa, Florida, Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968
Institutional Diet, *PHS*	April–June 1968	January 1969
Tri-City Diet, *HASL*	April–December 1967	June 1968

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Last presented
California	July–December 1967	December 1968
Coast Guard	1967	February 1969
Colorado River Basin	1967	December 1968
Florida	1967	February 1969
Minnesota	January–June 1968	February 1969
New York	June–December 1967	October 1968
Radiostrontium in Tap Water, *HASL*	January–June 1967	April 1968
Washington	July 1966–June 1967	August 1968

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, September 1968

Division of Pollution Surveillance
Federal Water Pollution Control Administration, Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity

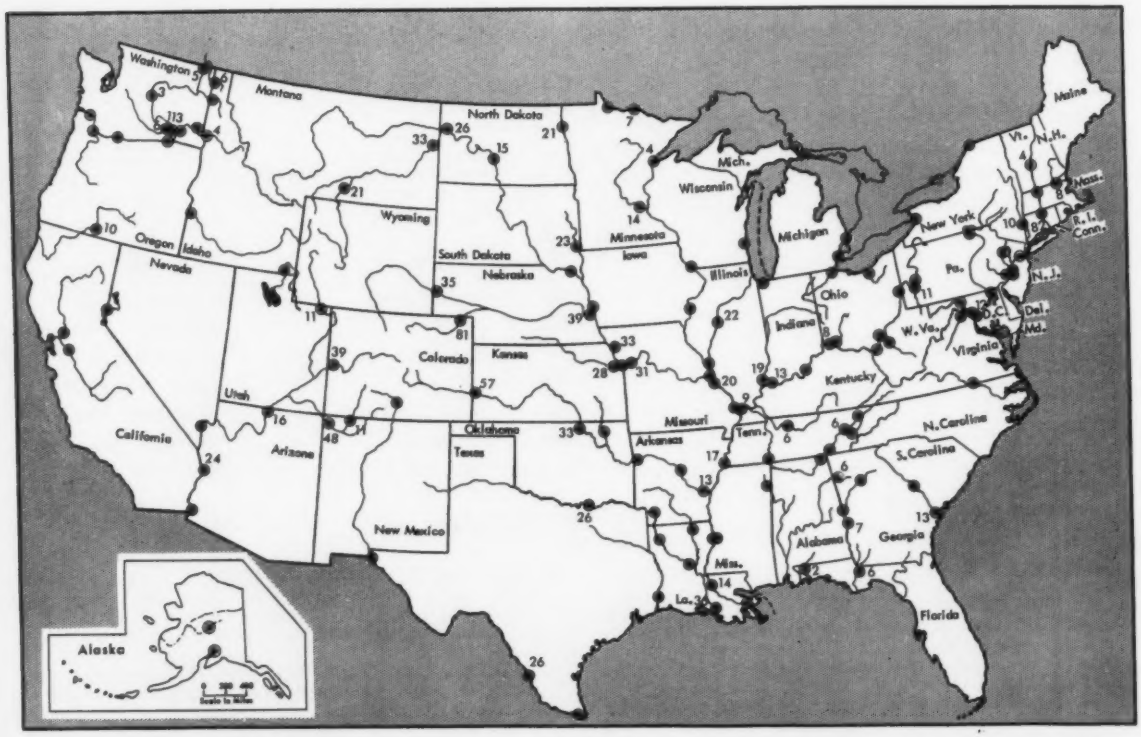

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, September 1968

per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During September 1968, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River: Julesburg, Colo.

No station showed a gross beta radioactivity in excess of 150 pCi/liter during September 1968.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1-15 (January 1968).

Table 1. Radioactivity in raw surface waters, September 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	0	2	2	3	8	11
Apalachicola River:						
Chatahoochee, Fla.	0	0	0	2	4	6
Arkansas River:						
Coolidge, Kans.	1	34	35	5	52	57
Ponca City, Okla.	2	6	8	7	26	33
Pendleton Ferry, Ark.	0	0	0	1	12	13
Atchafalaya River:						
Morgan City, La.	5	<1	5	24	12	36
Big Horn River:						
Hardin, Mont.	0	2	2	3	18	21
Big Sioux River:						
Sioux Falls, S. Dak.	1	1	2	3	20	23
Chattahoochee River:						
Columbus, Ga.	0	1	1	2	5	7
Clearwater River:						
Lewiston, Idaho	<1	0	<1	2	2	4
Clinch River:						
Kingston, Tenn.[a]	0	1	1	0	6	6
Colorado River:						
Loma, Colo.	1	11	12	9	30	39
Page, Ariz.	0	5	5	1	15	16
Parker Dam, Calif-Ariz.	0	5	5	3	21	24
Columbia River:						
Northport, Wash.	0	0	0	1	4	5
Wenatchee, Wash.	0	0	0	0	3	3
Pasco, Wash.[a]	0	1	1	54	59	113
Connecticut River:						
Wilder, Vt.	0	0	0	0	4	4
Enfield Dam, Conn.	0	0	0	3	6	9
Coosa River:						
Rome, Ga.	0	<1	<1	1	5	6
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	2	4	6
Escambia River:						
Century, Fla.	0	0	0	1	1	2
Great Lakes:						
Duluth, Minn.	0	0	0	1	3	4
Green River:						
Dutch John, Utah	0	2	2	1	10	11
Hudson River:						
Poughkeepsie, N.Y.	0	0	0	1	9	10
Illinois River:						
Peoria, Ill.	1	0	1	8	14	22
Kansas River:						
DeSoto, Kans.	2	2	4	11	17	28
Klamath River:						
Keno, Ore.	0	<1	<1	2	8	10
Merrimack River:						
Lowell, Mass.	0	0	0	2	6	8
Mississippi River:						
St. Paul, Minn.	0	1	1	1	13	14
E. St. Louis, Ill.	0	0	0	5	15	20
W. Memphis, Ark.	0	1	1	3	14	17
New Roads, La.	0	1	1	3	11	14
Missouri River:						
Williston, N. Dak.	2	2	4	8	18	26
Bismarck, N. Dak.	0	4	4	2	13	15
St. Joseph, Mo.	2	4	6	11	22	33
Missouri City, Mo.	1	2	3	8	23	31
Monongahela River:						
Pittsburgh, Pa.	0	0	0	1	10	11
North Platte River:						
Henry, Nebr.	<1	21	21	3	32	35
Ohio River:						
Cincinnati, Ohio	0	0	0	0	8	8
Evansville, Ind.	1	1	2	3	10	13
Cairo, Ill.	0	0	0	2	7	9
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	1	1	1	5	6
Platte River:						
Plattsmouth, Nebr.	6	3	9	22	17	39
Potomac River:						
Washington, D.C.	0	0	0	3	9	12
Rainy River:						
International Falls, Minn.	0	0	0	0	7	7
Red River, North:						
Grand Forks, N. Dak.	<1	2	2	3	18	21
Red River, South:						
Denison, Tex.	0	3	3	2	24	26
Rio Grande:						
Laredo, Tex.	2	3	5	10	16	26
San Juan River:						
Shiprock, N. Mex.	6	8	14	22	26	48
Savannah River:						
Port Wentworth, Ga.[a]	0	<1	<1	5	8	13
South Platte River:						
Julesburg, Colo.	1	41	42	5	76	81
Wabash River:						
New Harmony, Ind.	2	2	4	9	10	19
Yakima River:						
Richland, Wash.	<1	1	1	1	5	6
Yellowstone River:						
Sidney, Mont.	4	3	7	18	15	33
Maximum	6	41	42	54	76	113
Minimum	0	0	0	0	1	2

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network November 1968

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (1). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during November 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, November 1968

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Number of samples	Precipitation			
								Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average [a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	11	0	2	Sept 68	4	159	4	159	6
Alaska:	Adak	30	2	1	2	Feb 69	[c]				
	Anchorage	2	0	0	0	Oct 68	[c]				
	Attu Island	29	1	0	0	Mar 69	[c]				
	Fairbanks	[b]				Nov 68	[c]				
	Juneau	18	0	0	0	Dec 68	17	274	17	274	0
	Kodiak	17	1	0	0	Jan 69	[c]				
	Nome	[b]				July 68	[c]				
	Point Barrow	24	2	0	1	June 68	[c]				
	St. Paul Island	30	1	1	1	Aug 68	[c]				
Ariz:	Phoenix	17	14	1	7	Dec 68	[c]				
Ark:	Little Rock	[b]				Oct 68	[c]				
Calif:	Berkeley	18	1	0	0	Jan 69	5	55	5	55	2
	Los Angeles	[b]				July 68	[c]				
C.Z:	Ancon	14	0	0	0	Jan 69	[c]				
Colo:	Denver	18	6	1	3	Jan 69	3	7	[d]		
Conn:	Hartford	18	1	0	0	Nov 68	7	98	5	71	0
Del:	Dover	16	1	0	0	Sept 68	[c]				
D.C:	Washington	2	0	0	0	June 68	[c]				
Fla:	Jacksonville	19	10	0	1	Oct 68	2	10	2	10	11
	Miami	14	1	0	0	Nov 68	1	21	1	21	0
Ga:	Atlanta	17	2	1	1	Aug 68	3	165	3	165	145
Guam:	Agana	[b]				Sept 68	[c]				
Hawaii:	Honolulu	29	1	0	1	Mar 69	1	50	[d]		
Idaho:	Boise	18	9	0	3	Mar 69	4	26	3	25	16
Ill:	Springfield	19	3	1	1	June 68	3	42	0	0	[e]
Ind:	Indianapolis	17	3	0	1	Aug 68	6	108	6	108	61
Iowa:	Iowa City	17	7	0	1	Jan 69	3	35	3	35	0
Kans:	Topeka	18	2	0	1	Oct 68	4	36	4	36	2
Ky:	Frankfort	[b]				June 68	4	22	4	22	0
La:	New Orleans	16	1	0	0	June 68	4	96	[d]		
Maine:	Augusta	18	2	0	1	Dec 68	8	171	8	171	0
Md:	Baltimore	18	2	0	0	Nov 68	8	55	8	55	17
	Rockville	9	1	0	0	Mar 69	[c]				
Mass:	Lawrence	18	1	0	0	Sept 68	4	130	4	130	44
	Winchester	19	2	0	0	Feb 69	9	184	9	184	0
Mich:	Lansing	17	4	0	2	Mar 69	6	52	6	52	151
Minn:	Minneapolis	19	1	0	0	Sept 68	5	22	5	22	2
Miss:	Jackson	19	3	0	1	Dec 68	4	96	2	57	70
Mo:	Jefferson City	18	1	0	1	Aug 68	6	122	6	122	0
Mont:	Helena	15	5	0	2	Feb 69	4	4	4	4	5
Nebr:	Lincoln	18	4	0	2	Aug 68	3	27	3	27	18
Nev:	Las Vegas	17	2	0	1	Nov 68	[c]				
N.H:	Concord	17	1	0	0	June 68	[c]				
N.J:	Trenton	18	3	0	1	Dec 68	4	92	4	92	29
N. Mex:	Santa Fe	17	10	0	1	Feb 69	4	22	3	19	3
N.Y:	Albany	14	3	0	1	Aug 68	8	60	8	60	56
	Buffalo	18	1	0	0	Jan 69	[c]				
	New York City	17	1	0	1	Feb 69	[c]				
N.C:	Gastonia	14	15	1	4	Jan 69	2	18	[d]		
N.Dak:	Bismarck	18	4	0	1	June 68	3	9	3	9	0
Ohio:	Cincinnati	[b]				Sept 68	[c]				
	Columbus	15	5	0	1	Dec 68	7	101	0	0	[e]
	Painesville	20	1	0	1	Nov 68	10	12	10	12	6
Okla:	Oklahoma City	18	1	0	1	Mar 69	6	135	6	135	0
	Ponca City	20	4	0	1	Nov 68	6	91	6	91	0
Ore:	Portland	17	1	0	0	Aug 68	13	89	13	89	7
Pa:	Harrisburg	10	3	0	1	Aug 68	[c]				
P.R:	San Juan	[b]				Dec 68	[c]				
R.I:	Providence	17	1	0	0	Mar 69	7	108	7	108	47
S.C:	Columbia	14	3	0	1	Feb 69	5	106	5	106	39
S. Dak:	Pierre	12	10	2	5	Dec 68	[c]				
Tenn:	Nashville	13	1	0	1	Mar 69	7	154	7	154	6
Tex:	Austin	18	9	1	3	Sept 68	4	85	[d]		
	El Paso	15	9	0	3	June 68	[c]				
Utah:	Salt Lake City	29	4	0	1	July 68	8	40	6	38	9
Vt:	Barre	15	3	0	1	Oct 68	9	112	9	112	0
Va:	Richmond	11	1	0	0	Oct 68	2	24	2	24	14
Wash:	Seattle	15	0	0	0	Oct 68	11	88	[d]		
	Spokane	17	1	0	1	Sept 68	2	6	2	6	2
W. Va:	Charleston	9	1	0	1	Feb 69	10	49	9	45	12
Wisc:	Madison	19	1	0	1	Oct 68	6	41	6	41	57
Wyo:	Cheyenne	18	7	1	3	Nov 68	2	14	2	14	13
Network summary		1,116	15	0	1		2	88	6	74	21

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] Indicates no report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were reported.

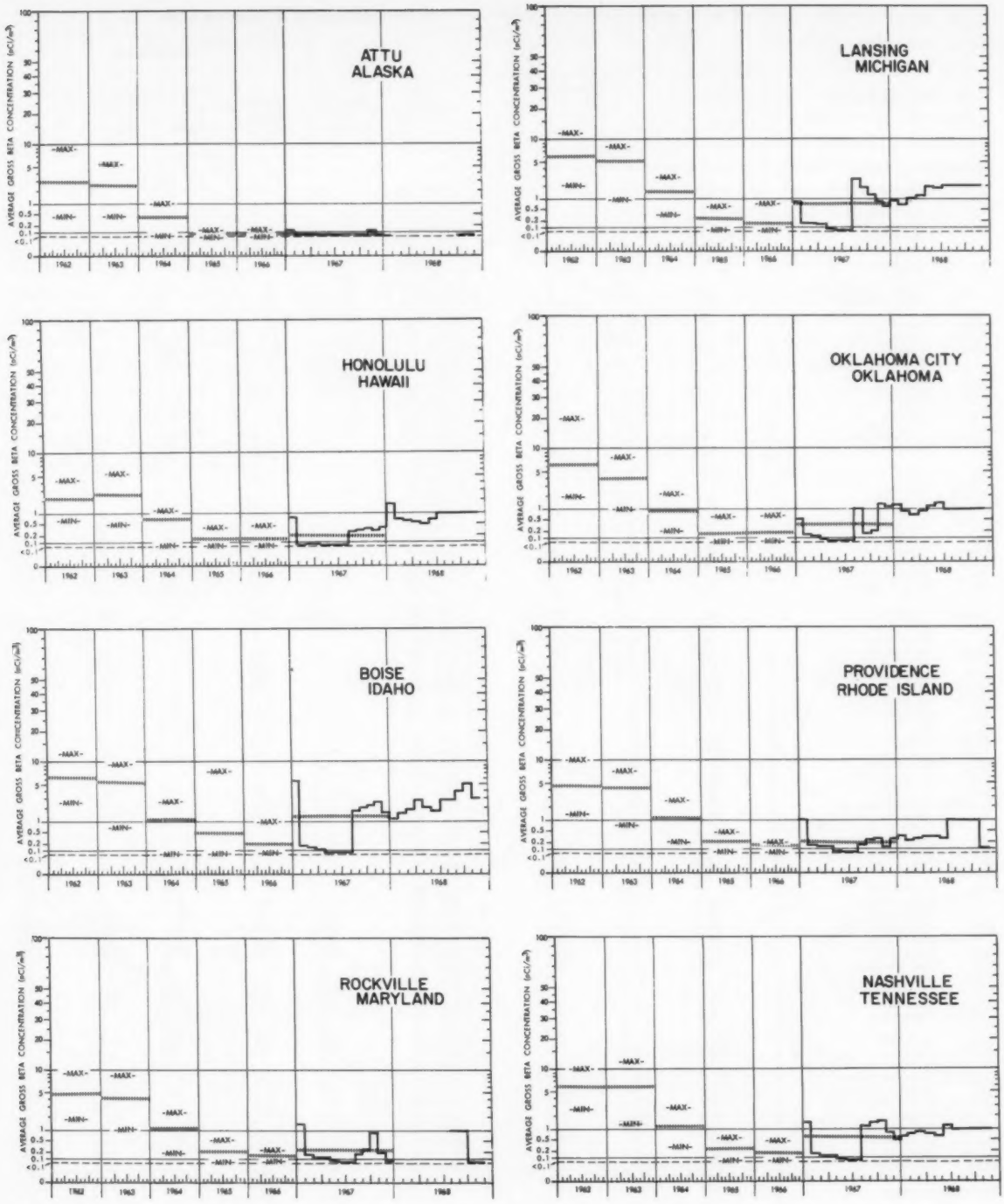

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, November 1968

2. Canadian Air and Precipitation Monitoring Program,[1] November 1968

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data in the December 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for November 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, November 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.1	0.0	0.0	NA	NA
Coral Harbour	30	.1	.0	.1		
Edmonton	30	.1	.0	.0		
Ft. Churchill	30	.1	.0	.0		
Ft. William	30	.1	.0	.0		
Fredericton	30	.0	.0	.0		
Goose Bay	30	.0	.0	.0		
Halifax	30	.1	.0	.0		
Inuvik	30	.1	.0	.0		
Montreal	30	.1	.0	.0		
Moosonee	25	.1	.0	.0		
Ottawa	30	.1	.0	.0		
Quebec	30	.0	.0	.0		
Regina	30	.1	.0	.0		
Resolute	30	.1	.0	.1		
St. John's, Nfld	29	.0	.0	.0		
Saskatoon	30	.1	.0	.0		
Saulte Ste Marie	30	.1	.0	.0		
Toronto	30	.1	.0	.0		
Vancouver	30	.1	.0	.0		
Whitehorse	30	.1	.0	.0		
Windsor	30	.1	.0	.0		
Winnipeg	20	.1	.0	.1		
Yellowknife	30	.1	.0	.1		
Network summary	704	0.1	0.0	0.0		

NA, no analysis reported.

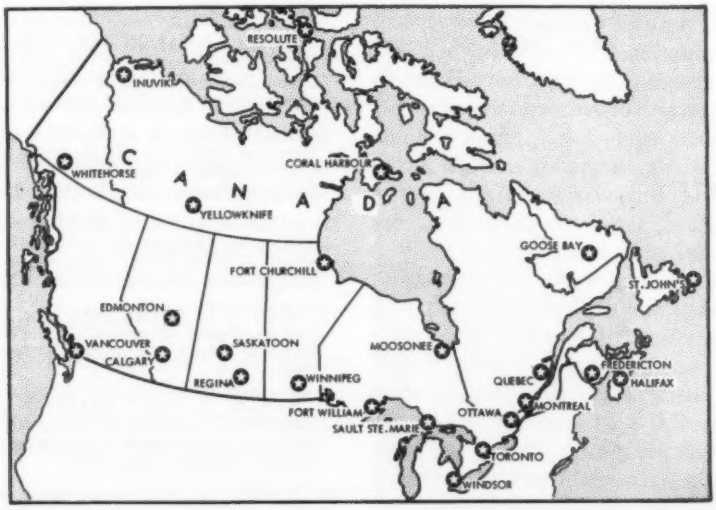

Figure 3. Canadian air and precipitation sampling stations

4. Pan American Air Sampling Program November 1968

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The November 1968 air monitoring results from the participating countries are given in table 3.

Table 3. Summary of gross beta radioactivity in Pan American surface air, November 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	6	0.39	0.26	0.32
Bolivia: La Paz	5	.42	.08	.30
Chile: Santiago	28	.53	.03	.27
Colombia: Bogota	7	.15	.01	.09
Ecuador: Guayaquil	15	.48	.11	.24
Guyana: Georgetown	7	.04	.01	.02
Jamaica: Kingston	21	.05	.01	.03
Peru: Lima	1	.41	.41	.41
Venezuela: Caracas	15	.21	.02	.07
West Indies: Trinidad	19	.14	.01	.04
Pan American summary	124	0.53	0.01	0.15

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

Figure 4. Pan American air sampling program stations

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. Bureau of Radiological Health, Office of Criteria and Standards, Rockville, Md. 20852 (Distribution by official request).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*4*) MAR, P. G. Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*5*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*6*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Offsite Surveillance for Three Events at the Nevada Test Site[1] January and March 1968

As a consequence of the U.S. Atomic Energy Commission's (AEC) underground nuclear testing program at the Nevada Test Site, three releases of low levels of radioactivity were detected offsite during the period, January through June 1968. The offsite monitoring program is conducted for the AEC under a memorandum of understanding by the Southwestern Radiological Health Laboratory of the Bureau of Radiological Health.

Project Cabriolet (*1*), a 2.5-kiloton nuclear excavation experiment conducted on January 26, 1968, as part of the Plowshare program, released a small amount of radioactivity to the environment north of the Nevada Test Site. The maximum external gamma radiation level measured during cloud passage at a populated location was 65 mR/hr. This was recorded by a permanent gamma-ray exposure rate recorder at Clark Station, Nev. A monitor using a portable survey instrument observed a maximum reading of about 43 mR/hr during cloud passage at the same location. Dosimeters used to document exposures from cloud passage plus 7 days of residual activity at Clark Station measured an integrated net exposure of 8 mR. An exposure rate of 20 mR/hr was measured at Stone Cabin Ranch near Clark Station with a portable survey instrument. Exposure rates measured at other offsite locations were over an order of magnitude less than the Stone Cabin values. A dosimeter located at Stone Cabin Ranch prior to cloud passage and collected 13 days following the experiment, showed an integrated net exposure of 8 mR. For this event, 275 milk samples from 51 stations were collected and analyzed. Forty-nine samples from 18 stations contained fresh fission products. Summaries of the peak results of air and milk sampling are shown in tables 1 and 2.

[1] This article is presented as a contribution from the U.S. Atomic Energy Commission.

Table 1. Five highest gross beta radioactivity and associated isotopic results from air sample filters, Cabriolet event January 26, 1968

Location	Time	Gross beta radioactivity (pCi/m³)	Gross beta radioactivity (pCi-hrs/m³)	Filter[a]	Iodine-131		Tellurium-iodine-132		Iodine-133		Iodine-135	
					(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)
Stone Cabin Ranch, Nev.	1020	33,000	160,000	PF	290	1,400	180	850	2,500	12,000	ND	ND
	1500			CC	72	340	56	260	2,900	14,000	ND	ND
Clark Station, Nev.	0730	15,000	130,000	PF	150	1,300	250	2,200	2,000	17,000	ND	ND
	1620			CC	110	960	69	600	3,300	29,000	ND	ND
Warm Springs, Nev.	0900	590	17,000	PF	2.7	76	4.0	110	53	1,500	ND	ND
	1415			CC	.4	11	1.0	28	12	340	ND	ND
10 miles west Warm Springs, Nev.	1045	2,000	13,000	PF	11	72	18	120	120	780	ND	ND
Highway 6 (unpopulated)	1715			CC	6.7	44	.4	2.6	150	980	ND	ND
Belleshellen Mine, Nev.[c]	1025	3,800	7,600	PF	18	36	29	58	290	580	ND	ND
	1235			CC	5.5	11	2.8	5.6	160	320	ND	ND

[a] PF—Particulate filter to collect particulate fission products.
CC—Charcoal cartridge, secondary to particulate filter, for collection of reactive gases, primarily iodine.
[b] January 25.
[c] Temporary sampler.
ND, nondetectable.

Table 2. Maximum iodine-131 radioactivity in milk samples from family milk cows following the Cabriolet event

Location	Date milked (1968)	Iodine-131 (pCi/liter)[a]
Mt. View Ranch, Death, Nev.	2/8	630
River Ranch, Death, Nev.	2/1	160
Cold Creek Ranch, Pancake Summit, Nev.	1/27	110
Martin Ranch, Potts, Nev.	1/28	110

[a] Extrapolated to date of milking.

Another Plowshare event, Project Buggy I (*2*), a cratering experiment consisting of a row of five 1.1-kiloton nuclear explosives, was conducted on March 12, 1968. A small amount of radioactivity was released to the environment north of the Nevada Test Site. Results show the highest external gamma-ray exposure rate observed in the offsite area was 8.5 mR/hr measured by a portable survey instrument during cloud passage 4 miles east of Warm Springs, Nev. The highest external gamma-ray exposure rate observed at a populated location was 1.5 mR/hr at Warm Springs. A dosimeter, which documented cloud passage plus 8 days of residual exposure at the location east of Warm Springs, showed an integrated net exposure of 11 mR. A dosimeter exposed at Warm Springs during the same period showed no exposure above background. Two hundred and ten milk samples from 48 stations

Table 3. Five highest gross beta radioactivity and associated isotopic results from air sample filters, Buggy I (March 12)

Location	Time	Gross beta radioactivity (pCi/m³)	Gross beta radioactivity (pCi-hrs/m³)	Filter[a]	Iodine-131		Tellurium-iodine-132		Iodine-133		Iodine-135	
					(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)
Warm Springs, Nev.	1037	12,000	59,000	PF	75	380	120	610	610	3,100	1,800	9,200
	1545			CC	22	110	26	130	310	1,600	2,500	13,000
Reed Ranch Nev.[b] (unpopulated)	1105	19,000	39,000	PF	46	92	72	140	250	500	820	1,600
	1305			CC	31	62	40	80	360	720	800	1,600
Eureka, Nev.	0700	3,800	38,000	PF	16	160	40	400	110	1,100	ND	ND
	1700[c]											
Blue Jay, Nev.	0705	3,900	35,000	PF	23	200	29	260	160	1,400	570	5,100
	1615			[d]CC	20	100	25	130	300	1,500	1,200	6,100
Twin Springs, Nev.	0800	910	6,000	PF	4.6	35	5.5	42	34	260	120	910
	1525			CC	4.2	32	5.1	39	47	360	90	690

[a] PF—Particulate filter to collect particulate fission products.
CC—Charcoal cartridge, secondary to particulate filter, for collection of reactive gases, primarily iodine.
[b] Temporary sampler.
[c] No charcoal cartridge.
[d] CC added 3/12, 1110 to 1615.
ND, nondetectable.

were collected for this event. Seventy-one samples from 20 stations contained fresh fission products. Summaries of peak results from air and milk sampling are shown in tables 3 and 4.

Table 4. Maximum iodine-131 radioactivity in milk samples from family milk cows following the Buggy I event

Location	Date milked (1968)	Iodine-131 (pCi/liter)[a]
Pohlsander Ranch, Wells, Nev.	3/15, 3/16	550
Circle Ranch, Pancake Summit, Nev.	3/15	100
Mt. View Ranch, Deeth, Nev.	3/16	90

[a] Extrapolated to date of milking.

The Hupmobile event, a low yield[2] underground nuclear weapons test conducted at the Nevada Test Site on January 18, 1968 (*1*), released very low levels of radioactivity to the offsite environment. The maximum portable survey instrument reading was 0.7 mR/hr at Dansby's Ranch near Lathrop Wells, Nev., and also 4 miles west of Lathrop Wells on Highway 95. Dosimeters placed at several downwind locations detected no exposures above natural background. Of the 45 milk samples collected from 16 stations, 3 stations showed fresh fission products in 4 samples. Summaries of peak results from air sampling are shown in table 5. The maximum iodine-131 radioactivity in milk samples from family milk cows was 30 pCi/liter which occurred at the Rooker Ranch, Lathrop Wells, Nev. on January 18, 1968.

Concentrations in air and milk from all three events are extrapolated to the end of air sampling period and date of milking, respectively.

The low levels of radioactivity released to the environment by these events did not exceed those safety criteria established in Chapter 0524, Standards for Radiation Protection, of the AEC Manual.

[2] Low yield is defined as 20 kilotons or less TNT equivalent.

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Reported nuclear detonations, January 1968. Radiol Health Data Rep 9:142 (February 1968).

(*2*) U.S. ATOMIC ENERGY COMMISSION. Reported nuclear detonations, March 1968. Radiol Health Data Rep 9:240 (April 1968).

Table 5. Five highest gross beta radioactivity and associated isotopic results from air sample filters Hupmobile

Location	Time	Date	Gross beta radioactivity (pCi/m³)	Gross beta radioactivity (pCi-hrs/m³)	Filter[a]	Iodine-131		Tellurium-iodine-132		Iodine-133		Iodine-135	
						(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)
Dansby's Ranch[b] Amargosa Valley, Nev.	0935	1/18	1,100	9,000	PF	*ND	ND	260	2,100	30	240	980	7,900
	1715	1/18			CC	ND	ND	ND	ND	53	430	630	5,100
Lathrop Wells, Nev.	0825	1/18	310	3,700	PF	ND	ND	90	1,100	12	140	270	3,200
	2010	1/18			CC	ND	ND	ND	ND	21	250	250	3,000
Death Valley Junction, Calif.	0630	1/18	210	1,900	PF	ND	ND	42	390	5.6	52	190	1,700
	1540	1/18			CC	ND	ND	ND	ND	5.1	47	180	1,700
Shoshone, Calif.	0952	1/18	8.0	190	PF	1.0	24	3.9	92	6.1	140	ND	ND
	0925	1/19			CC	ND	ND	ND	ND	ND	ND	ND	ND
Barstow, Calif.	0700	1/19	2.8	68	PF	.3	7.2	1.6	39	3.3	80	ND	ND
	0700	1/20			CC	ND	ND	ND	ND	ND	ND	ND	ND

[a] PF—Particulate filter to collect particulate fission products.
CC—Charcoal cartridge, secondary to particulate filter, for collection of reactive gases, primarily iodine.
[b] Temporary sampler.
ND, nondetectable.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Bettis Atomic Power Laboratory, and the SIC Prototype Reactor Facility.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Bettis Atomic Power Laboratory[2] January–December 1967

Westinghouse Electric Corporation
Pittsburgh, Pa.

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pa. Routine environmental monitoring data from the sampling locations shown in figure 1 show no significant contribution from laboratory operations to environmental radioactivity levels.

Gaseous radioactive waste

The release of gaseous radioactive waste is monitored by continuous air sampling to assure compliance with laboratory regulations. The stack gas limits for the laboratory are based on the 168-hour nonoccupational MPC in air as specified in AEC Manual Chapter 0524. At no time during 1967 did the concentration of stack releases exceed the required limits. The general public outside the boundary of the laboratory was not exposed to radiation above normal background levels.

Total gaseous radioactivity released to the environment during 1967 was 1.16 mCi alpha and 76 mCi beta-gamma. This compares favorably with 2.9 mCi alpha and 340 mCi beta-gamma radioactivity released during 1966.

Liquid radioactive waste

Liquid effluent discharged from the laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta-gamma radioactivity, and quarterly for strontium-90 radioactivity.

The average concentrations of gross beta radioactivity in the main laboratory liquid effluent during 1967 was 520 pCi/liter. This was slightly lower than the average concentration of 540 pCi/liter observed for the last 6 months of 1966.

The average concentration of gross alpha radioactivity in the main laboratory effluent was 4.7 pCi/liter; a reduction from the 5.6 pCi/liter average for the July–December 1966 period.

Average radioactivity in liquid waste effluent from the critical facility operations during 1967 were: alpha radioactivity <400 pCi/liter, beta-gamma radioactivity—1.36×10^3 pCi/liter. Comparable values for the last 6 months in 1966 were 130 pCi/liter for alpha radioactivity and 520 pCi/liter for beta-gamma radioactivity.

[2] Summarized from "Bettis Atomic Power Laboratory, Environmental Monitoring Report, Calendar Year 1967" (WAPD-O-(IHR)-1035).

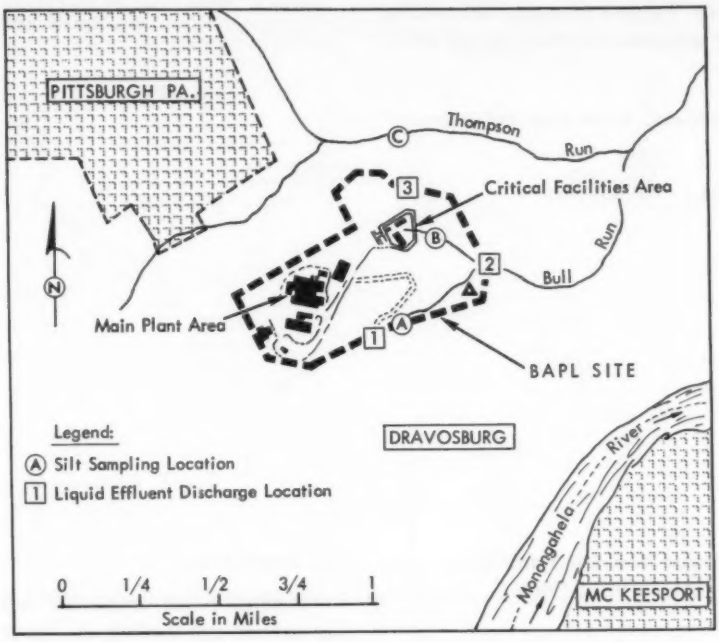

Figure 1. Bettis Atomic Power Laboratory sampling stations

Background monitoring stations

Background beta-gamma radiation levels were continuously monitored and recorded at 34 film badge monitoring stations located at 100-yard intervals along the boundary of the laboratory property which lies within the controlled confines of the Bettis Atomic Power Laboratory site.

The average beta-gamma background radiation level during 1967 was 0.072 mR/hr for the main laboratory area and 0.046 mR/hr for the critical facility area. The respective average exposure values for July through December 1966 were 0.051 mR/hr and 0.010 mR/hr. Table 1 summarized results obtained during 1967 from the background monitoring stations.

Table 1. Beta-gamma background radiation monitoring, Bettis, 1967

Location	Exposure levels (mR/hr)	
Main laboratory area (20 locations)	Maximum	0.729
	Average	.072
Critical facility area (14 locations)	Maximum	.020
	Average	.009
All locations	Average	.046

Stream silt

Stream silt samples were collected quarterly at the three locations shown in figure 1. The results of analysis of these samples are presented in table 2. The average alpha and beta-gamma radioactivity concentrations of stream silt samples for 1967 were 4.5 pCi/g and 32 pCi/g, respectively. Although these concentrations represent an increase over those for 1966, they are consistent with or below concentrations detected in previous years.

Table 2. Radioactivity in stream silt, Bettis, 1967

Period 1967	Number of samples	Radioactivity (pCi/g)			
		Alpha		Beta-gamma	
		Range	Average	Range	Average
January–March	3	0.7–5.7	3.6	2.1–53	28
April–June	3	2.2–6.5	4.2	7.2–27	15
July–September	3	2.4–3.8	2.9	4.3–30	17
October–December	3	5.5–8.0	7.0	14. –73	53

Semiannual analyses for strontium-89 and strontium-90 were obtained for composites of

quarterly silt samples. Table 3 presents the results of these analyses for samples collected during 1967.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1966	April 1967
July–December 1966	October 1967

Table 3 Strontium-89 and strontium-90 in stream silt, Bettis, 1967

Period 1967	Concentration (pCi/g of silt)	
	Strontium-89	Strontium-90
January–June	<0.09	0.74
July–December	< .09	.21

2. S1C Prototype Reactor Facility[3] January–December 1967

Combustion Engineering, Inc.
Windsor, Conn.

The S1C Prototype Reactor Facility is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C Prototype Facility began in December 1959.

The low level radioactive waste discharged intermittently from S1C prototype operations consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially, all of the radioactive waste originates from the activation of minute amounts of impurities or corrosion products in the circulating water used as a reactor coolant. All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations.

[3] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report for 1967."

Air monitoring

Ventilation air from the submarine hull and the supporting facility at the prototype site may contain small amounts of radioactive gases or particulates. This ventilation air is discharged to the environment through an exhaust stack and is continuously monitored for radioactivity by automated counters which control the discharge of the exhaust air. When the AEC maximum permissible concentration limits are exceeded, the exhaust air is discharged through a high-efficiency filter bank or the ventilation system is completely shut down and the hull sealed. In addition, air is continuously sampled for particulates at onsite and offsite locations shown in figure 2.

Liquid radioactive waste

Drainage from all systems which are known to contain radioactive liquids were collected, processed and sampled prior to discharge to the environment to assure that discharge concentrations were within the required limits. In addition, waste effluent is sampled as it is discharged to the environment. These samples are analyzed for radioactivity and the results are retained as part of the permanent records.

The S1C prototype discharged a total of 1.2×10^6 gallons of radioactive liquid waste containing 11.7 millicuries of radioactivity during 1967 for an annual average discharge concentration of 2.4 nCi/liter.

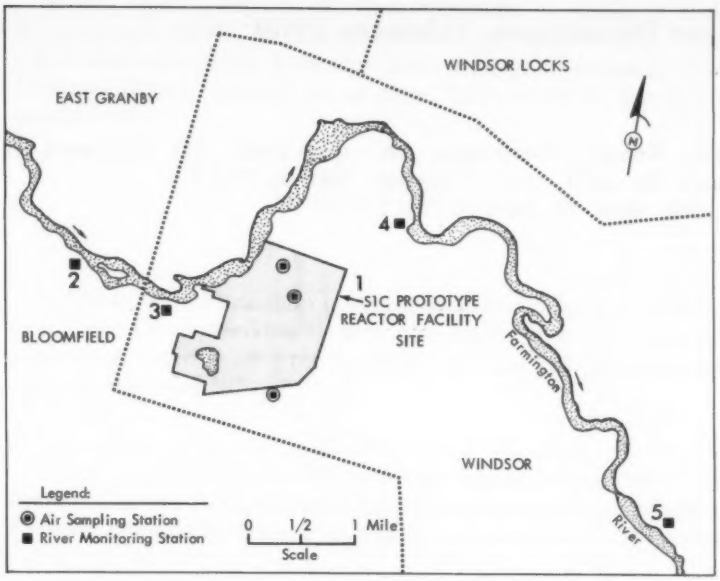

Figure 2. Environmental monitoring locations, S1C prototype site

Water monitoring

Water and sediment samples from the Farmington River are taken quarterly and analyzed. These samples are used to determine if buildup (reconcentration of radioactivity) is occurring.

The Farmington River was sampled at the outlet of the S1C Prototype discharge brook. During 1967, gross gamma radioactivity of water samples from the outlet of the S1C discharge brook ranged from 13 to 130 pCi/liter which is well below the 3.0×10^4 pCi/liter maximum permissible concentration specified by the Federal Regulations for cobalt-60, the most limiting radionuclide in S1C wastes. During 1967, the techniques used to analyze for radioactivity in water samples were changed from beta-particle to gamma-ray counting. This provides better detection of small changes in radioactivity levels.

Airborne radioactivity

All areas on site where gaseous and/or particulate airborne radioactivity could be present are directed through ducts to monitored stacks. The stacks are monitored for airborne levels on a continuous basis. The facility's operational controls ensure that the radioactive concentration in the environment does not exceed the 1,000 pCi/m³ limit. This limit is based on levels of strontium-90 and alpha-particle emitting isotopes being insignificant.

The airborne particulate radioactivity samples taken during discharge are recounted 4 hours after discharge. The delay allows short-lived radioactivity to decay. The air effluent analysis records indicate that no significant air-borne radioactivity was discharged above natural background levels.

Conclusions

Results of the analyses and of the continuous monitoring throughout 1967 have indicated that S1C Prototype operations have met all of the Federal Regulations pertaining to radiation protection standards. Environmental analyses indicate that no significant quantities of radioactivity have accumulated above the pre-operational environmental results. It is, therefore, concluded that the facility operations have not adversely affected the surrounding environment.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1966	April 1967
July–December 1966	October 1967

Reported Nuclear Detonations, February 1969

The U.S. Atomic Energy Commission announced on February 12, 1969, that a nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground at its Nevada Test Site.

Errata

The data reported for the Hudson River Station at Poughkeepsie, N.Y., and the Savannah River station at Augusta, Ga., in table 1 of the article "Tritium in Surface Waters of the United States, 1966" (Radiological Health Data and Reports 9:338, July 1968) is incorrect. The correct data appears below and should be inserted in this article.

Table 1. Tritium concentration in surface waters, in the United States, 1966

Collection site	Concentration (nCi/liter)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Hudson River: Poughkeepsie, N.Y.	<2.0	2.5±2.0	5.1±0.5	<4.1	<4.1	6	2.9±0.7	2.8±0.7	2.0±0.6	2.9±0.3	1.7±0.3	1.6±0.3
Savannah River, Augusta, Ga.	<2.0	6	6	6	6	2.2±0.6	1.4±0.6	1.5±0.6	6	1.6±0.6	3.0±0.4	2.6±0.3

In the report "Cesium-137 Concentrations in Alaskans during the Spring of 1967" by Rechen, Mikkelsen, Briscoe and Steiner, which appeared in the December 1968 issue of *Radiological Health Data and Reports*, formula (4) on page 709 is incorrect. The formula should read:

$$\frac{\text{nCi}}{\text{kg–CPM}} = \frac{0.0134}{(\text{W})^{0.3}}$$

In the article "Plutonium in Airborne Particulates and Precipitation, July–December 1967" which also appeared in the December 1968 issue, there is an error in table 5 on page 763. The plutonium ratio should read $^{239}Pu/^{238}Pu$.

In the article "Savannah River Plant, January–June 1968" which appeared in the January 1969 issue of *Radiological Health Data and Reports*, the data in table 4 on page 41 are incorrect. The corrected table appears below:

Table 4. Total fallout deposited, Savannah River Plant, January–June 1968

Radionuclide	Deposition (nCi/m²)																
	Plant perimeter locations						25-mile-radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha[a]	2.8	3.7	2.4	6.9	7.4	4.6	3.6	2.0	6.1	2.2	2.2	6.2	1.2	5.3	3.5	5.2	3.7
Strontium-89	.4	.1	ND	.3	.1	.2	.2	.3	.5	.3	.1	.1	.2	.2	.1	.04	.2
Strontium-90	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4	.3	.3	.4	.4	.3
Cesium-137	.4	.7	.5	.5	.6	.6	.6	.6	.4	.5	.9	.8	.6	.6	.5	.7	.6
Cerium-141, 144	2.6	2.3	3.6	2.0	2.4	2.5	4.0	1.6	2.2	3.2	3.1	2.7	1.8	1.1	2.4	2.6	2.5
Zirconium-niobium-95	3.5	3.0	4.4	2.5	3.5	3.4	5.4	1.7	2.7	5.3	5.2	4.0	2.8	1.8	3.6	4.0	3.7
Beryllium-7	9.5	14.1	18.3	12.4	14.8	13.8	8.8	4.5	12.0	11.9	14.3	13.9	4.6	8.6	7.1	11.1	9.7
Ruthenium-106	ND	ND	.8	ND	.4	.2	1.1	ND	ND	.7	.8	ND	.7	ND	ND	ND	.3

[a] Multiply by 10^{-3}.
ND, nondetectable, less than sensitivity of analysis.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

IMPROVEMENT IN NEW YORK CITY X-RAY INSTALLATIONS DURING THE FIRST SEVEN YEARS OF A RADIATION CONTROL PROGRAM. *Hanson Blatz and Daniel E. Lynch. Radiological Health Data and Reports, Vol. 10, March 1969*, pp. 89–92.

The percentage of private medical radiographic units in New York City free from described deficiencies increased from 8 to 73 percent between 1959 and 1966; for dental radiographic units the increase was from 47 to 89 percent. The percentage of medical radiographic units considered to have adequate x-ray beam filtration increased from 75 to 95 percent in this period; for fluoroscopes the improvement was from 81 to 94 percent; and for dental machines, from 66 to 96 percent. Also, during the period the percentage of machines possessing adequate beam limitation increased as follows; for medical radiographic units, 34 to 90 percent; for fluoroscopic units, 40 to 83 percent; and for dental units, 73 to 94 percent.

KEYWORDS: Dental radiography, equipment, fluoroscopy medical radiography, New York City, radiation control, survey, x ray.

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